

## **Production and application of char in agriculture - in a system perspective**

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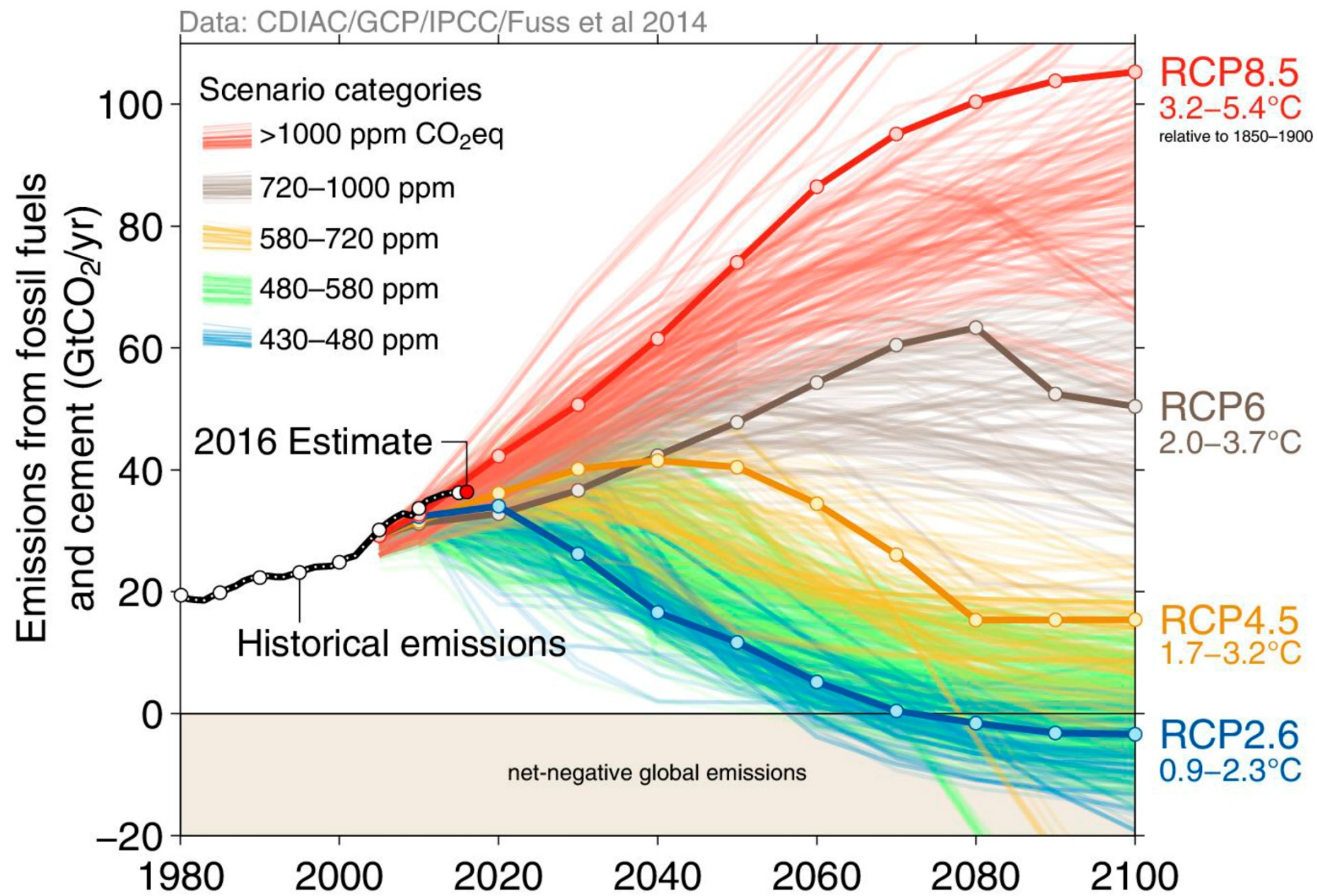
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DTU KT, INBIOM and NORDIC BIOCHAR NETWORK - Char and biochar workshop F2019

# Production and application of char in agriculture **in a system perspective**

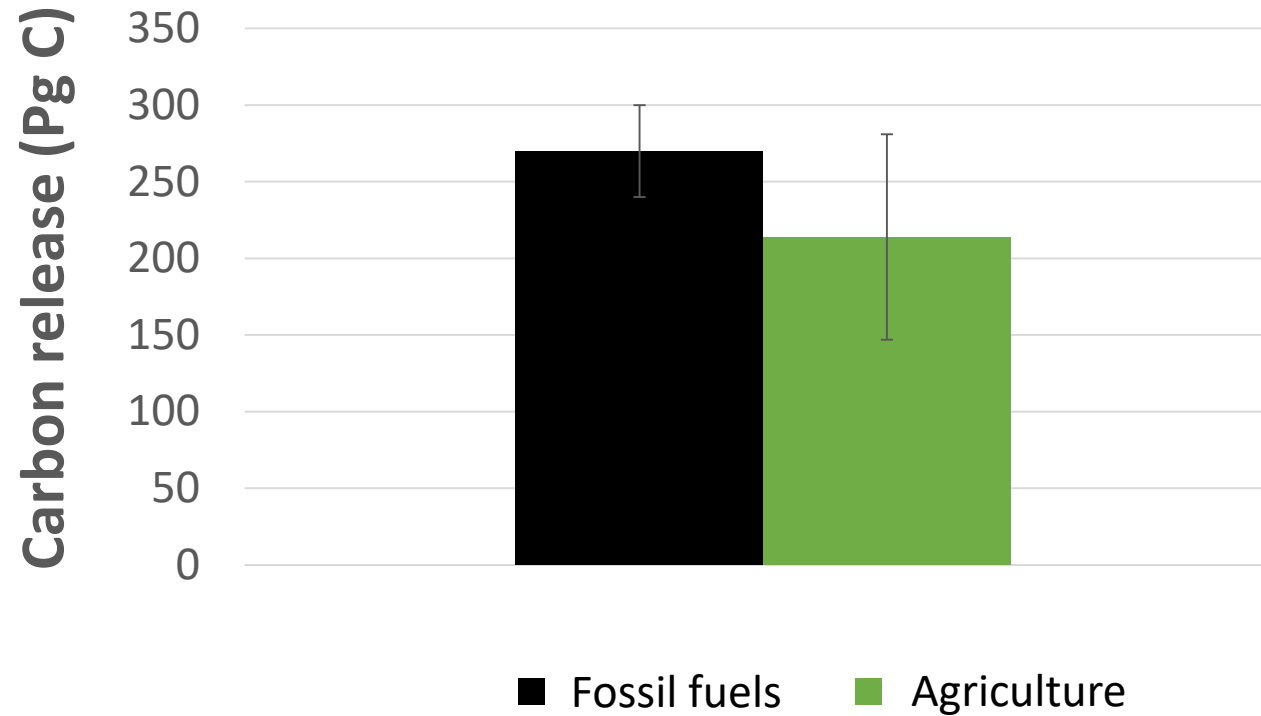
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Source: The IPCC Fifth Assessment Report

# Accumulated anthropogenic carbon release



Source: Zomer et al., 2017, Global Sequestration Potential of Increased Organic Carbon in Cropland Soils



Focus on potential environmental benefits within:

- 1 | Mitigation of Climate Change
- 2 | Controlling nutrient loops

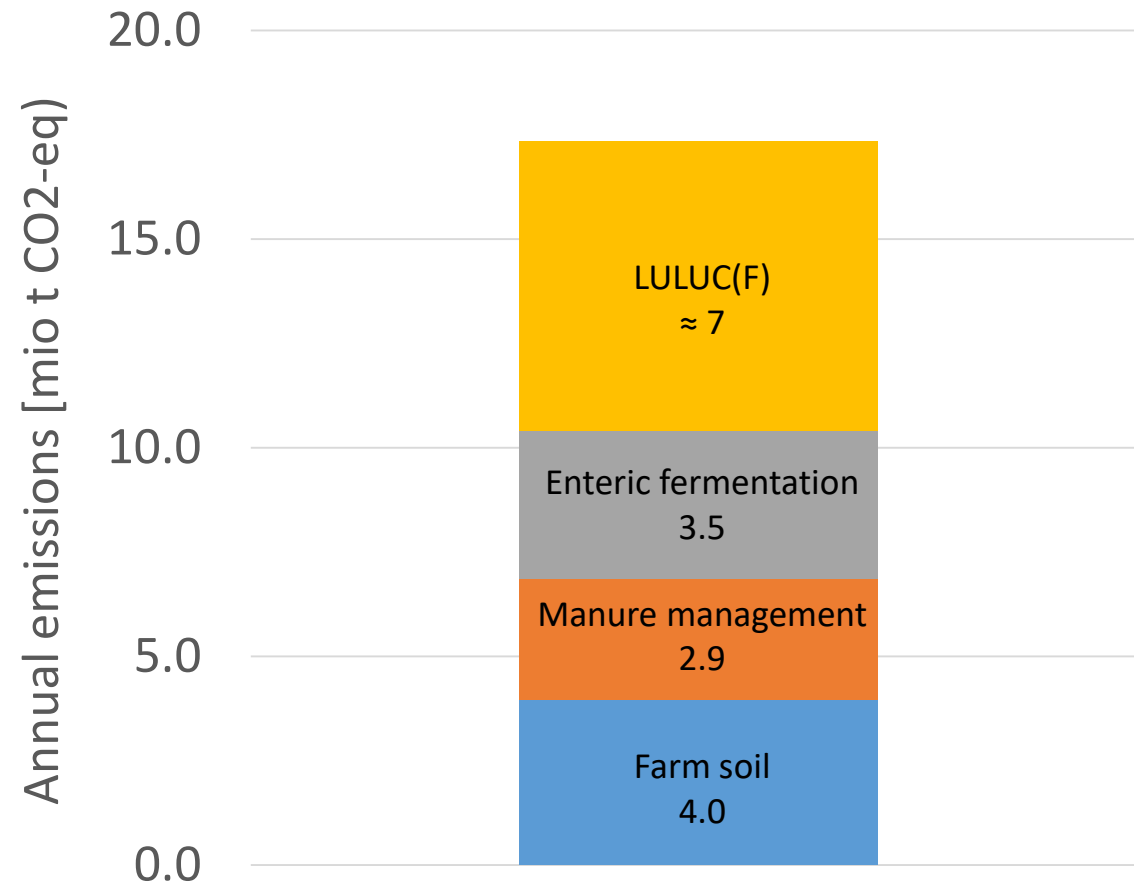
## Status | greenhouse gas emissions from Danish agriculture

- 21% of total greenhouse gas emissions

- 89% of total  $\text{N}_2\text{O}$
- 81% of total  $\text{CH}_4$
- 1% of total  $\text{CO}_2$

( $\approx 4.7$ ,  $5.5$  and  $0.2$  mio t  $\text{CO}_2\text{-eq/year}$ )

- + LULUC(F), around 14% of DK emissions



Source: AU "DENMARK'S NATIONAL INVENTORY REPORT 2018" and AU "DANISH EMISSION INVENTORIES FOR AGRICULTURE, Inventories 1985 – 2015" and Klimarådet (2018) "Effektive veje til drivhusgasreduktion i landbruget"



## Potentials | Abatement of field N<sub>2</sub>O emissions

- Char often contains very small amounts of N
- Manure char + mineral N -> lower emissions than raw or composted manure fibers (Zhu et al 2014)
- Soil-N and fertilizer-N N<sub>2</sub>O emissions inhibition up to 30% by use of e.g. wood pyrolysis char (e.g. Borchard et al 2018 and Cayuela et al 2014)
- NH<sub>3</sub> emissions avoided -> precursor for N<sub>2</sub>O in adjacent systems



## Potentials | Stabilization and improved management

### Pyrolysis of organic residues and wastes

- > Stabil storage and improved transportation and handling
- > Severely reduce emissions of methane and nitrous oxide (+  $\text{NH}_3$  and odor)

#### Characterization factors for $\text{CH}_4$

Normal approach	100 years	28
New normal?	20 years	84



Perspective: Apply char on/under stable floors, on ventilation air or in storage tank to adsorb  $\text{NH}_3$ , add value to char and reduce emissions

Source: IPCC "Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change", Appendix 8A







## Potentials | Char as dietary supplement?

- Carbon as pharmaceutical or dietary supplement already commercial in pure form in several countries
- May stabilize digestion and reduce CH<sub>4</sub> release from cows
- May increase meat quality in boar pigs
- Can also stabilize human digestion system



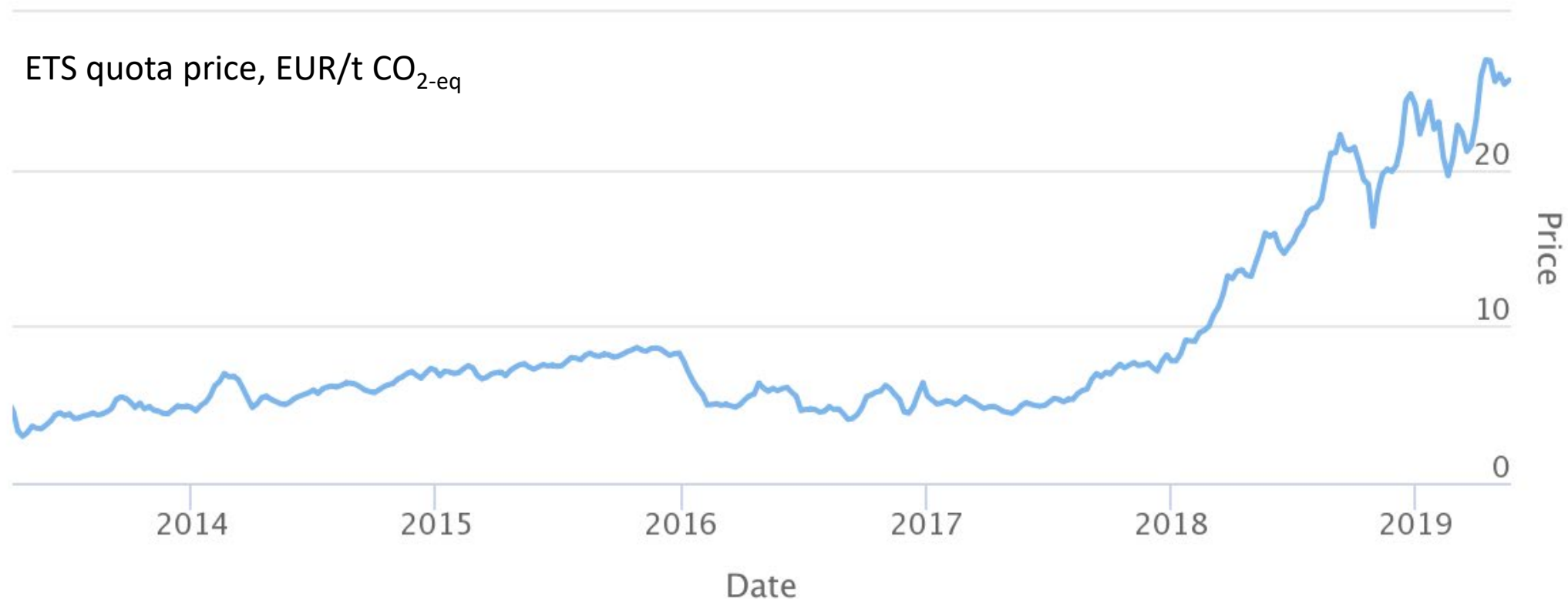


## Potentials | C-sequestration

- Highly recalcitrant carbon char matrix (Sander B.)
  - > Carbon sequestered, low tech and highly efficient
- Char in soil is more than carbon sequestration
  - Improves water infiltration and water retention
  - Retain nutrients from leaching
  - Increase pH
  - Improves soil structure -> reduce field work energy requirements
  - Increase quality and robustness of biom by creating shelter
  - More, on the next workshop?
- Carbon credit prices may be a "new" incentive?



# Potentials | C-sequestration



Source: <https://sandbag.org.uk/carbon-price-viewer/>

## Potentials | Energy production - a bonus mitigation mechanism

- Hard case - Sludge, manure fibers, digestate and similar: Around 25 PJ heat products < 100 C due to high moisture content and drying requirements
- Easy case - Straw: Around 50 PJ, heat, gas or oil products used e.g. for process heat, peak load in boilers – or as bunker fuel?
- Mixed case: Straw + sludge etc.: 75 PJ with good fuel and char characteristics - and no need for drying
- Total DK pyrolysis bioenergy product potential (excl char) 70-120 PJ.

**Substituting 10 PJ bunker fuel reduce GHG emissions with almost 1 mio t CO<sub>2</sub>-eq!**



Focus on potential environmental benefits within:

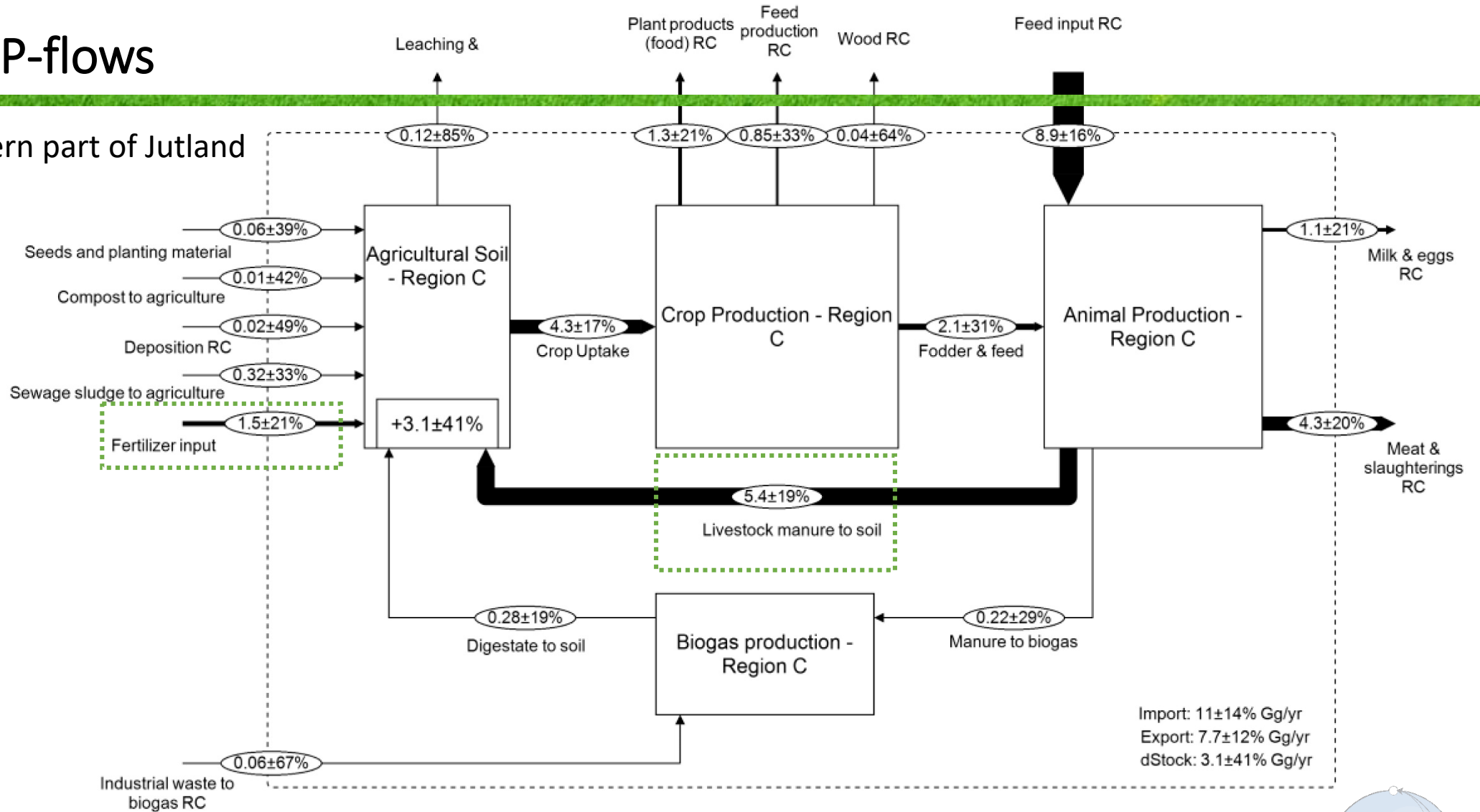
1 | Mitigation of Climate Change

2 | Controlling nutrient loops

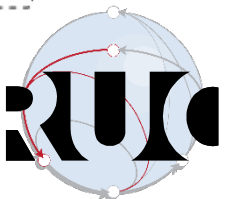


# Status | P-flows

Case: Northern part of Jutland



Source: Klinglmair, M. (2016) Anthropogenic phosphorus flows in Denmark: Quantification and critical analysis

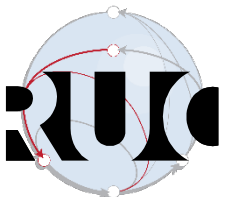




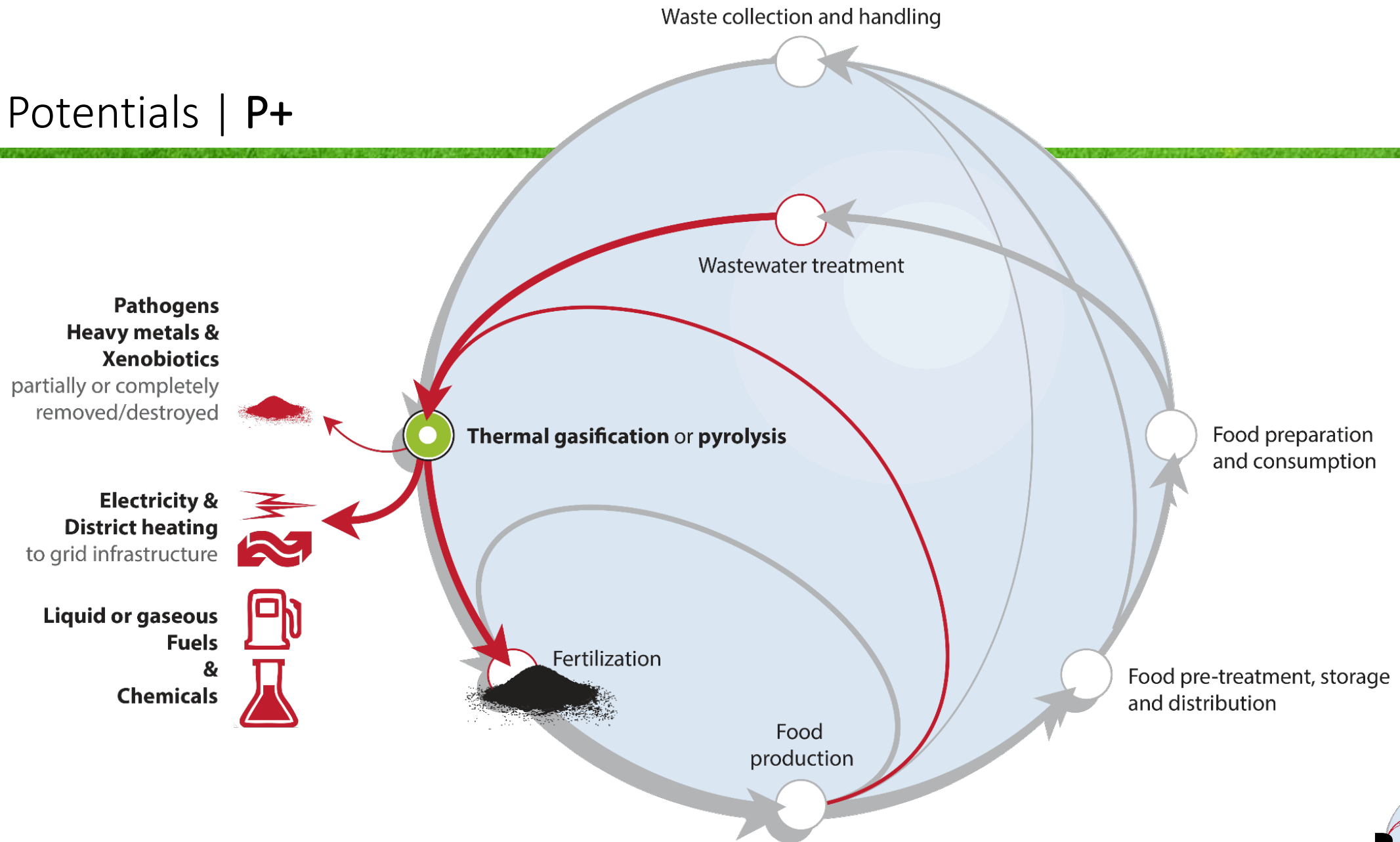
## Status | Current management strategies

Controlling nutrient loops by management of organic residues and wastes:

- Direct field application
- Composting
- Anaerobic digestion
- Separation
- Incineration



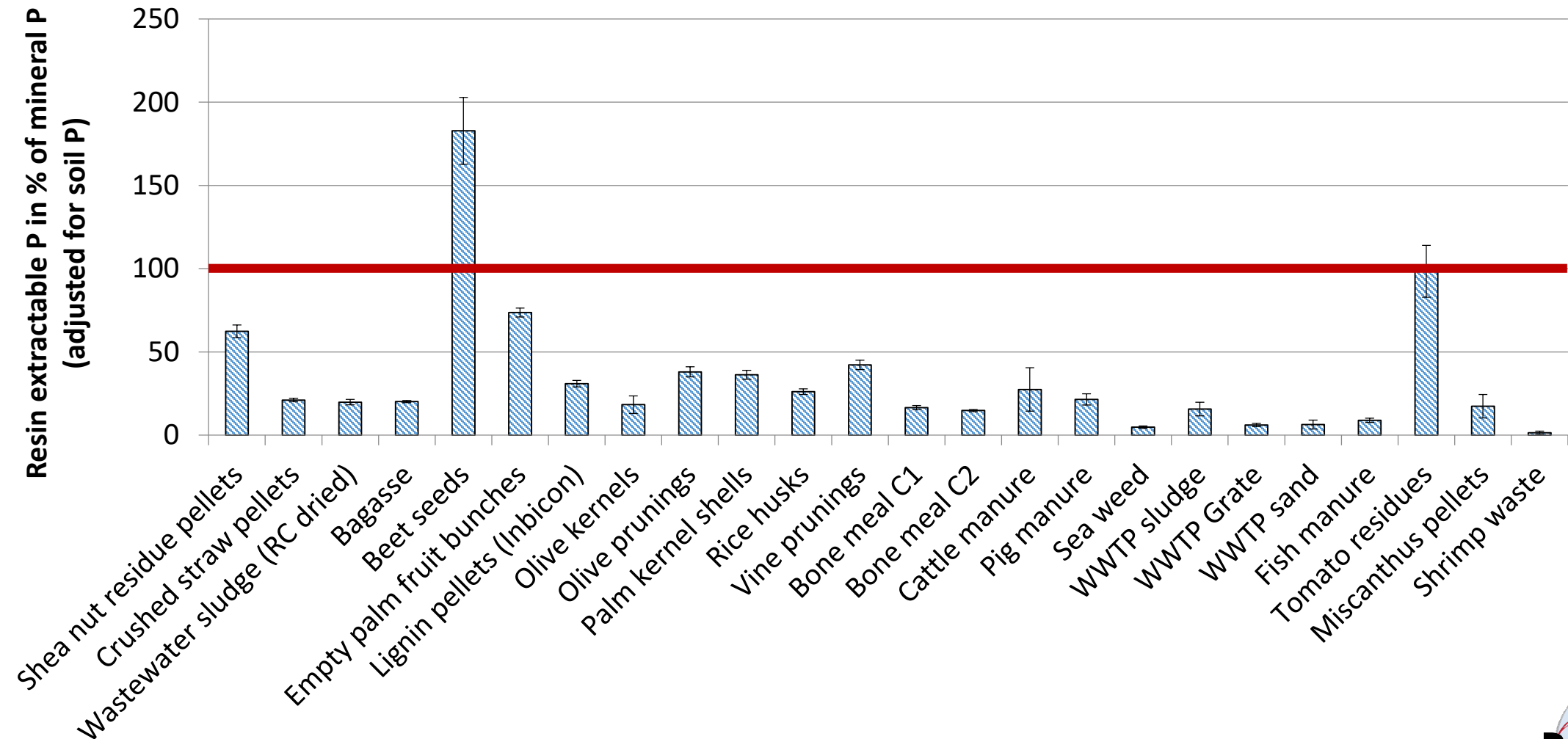
# Potentials | P+



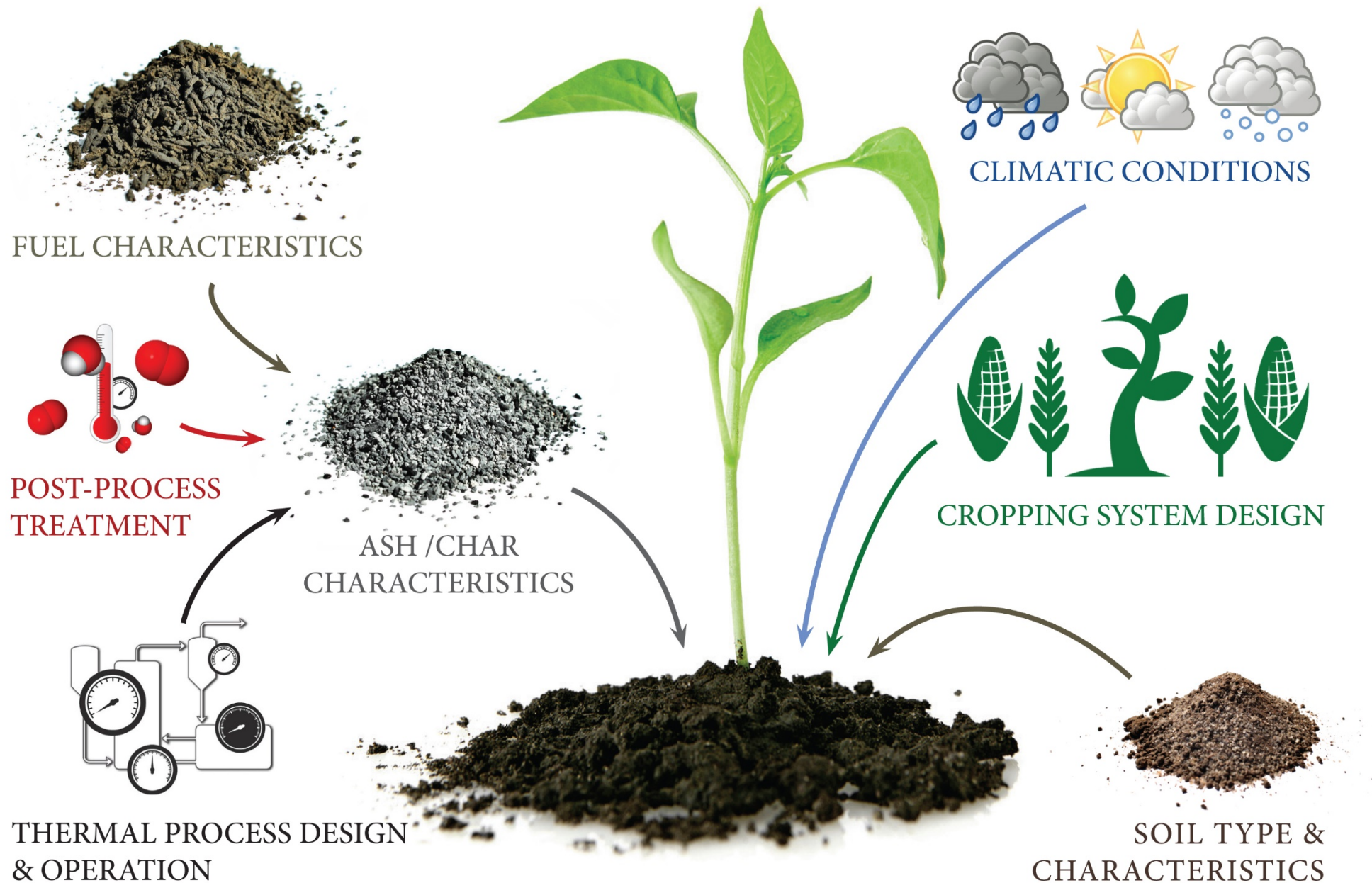
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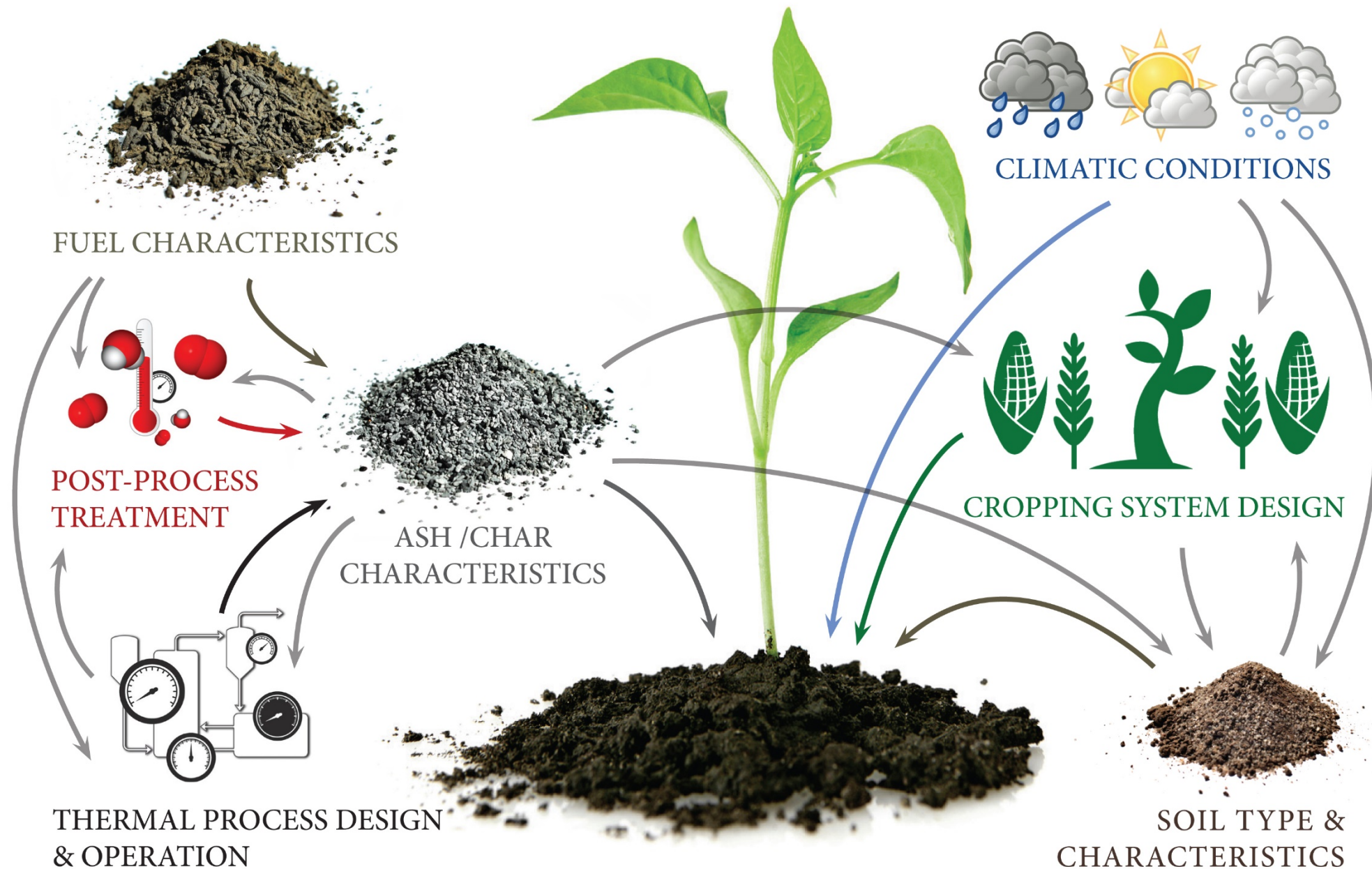


# Potentials | P+



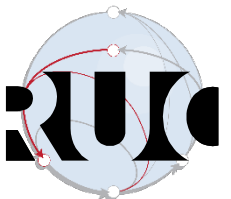






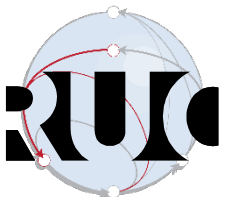
# Potentials | P+

- Thermal purification
  - Removing or reducing heavy metals e.g. Hg, Cd, As, Zn
  - Destroying pathogens
  - Destroying other xenobiotics in manure, sludge and digestate e.g.
    - Antibiotics, growth hormones and other pharmaceuticals
    - Pesticides, fungicides, herbicides
    - Dewatering polymers (Polyacrylamide)
    - Surfactants, phthalates, solvents
    - etc.



## Issues | N-loss in thermal processes

- N loss is a common downside of thermal processing of biogenic materials
- Losses of 60-80% are common and residual N is not plant available
- N is essential for plant growth
- The value loss is associated with the N quality in the feed stock
- However, N is not a critical, or even limited, resource (like P)
- N can be sourced from the air to the soil by growing e.g. legumes
- Fueling a Haber-Bosch process with hydrogen from electrolysis can provide sustainable replenishment
- Using char to adsorb  $\text{NH}_3$  will reduce net loss







# Pyrolysis in agriculture

## One size fits all?





## Applicable? | Climate change mitigation

High level of knowledge and certainty:

- Stabilization
- Carbon sequestration
- Energy production

More R&D required and/or higher level of uncertainty:

- N<sub>2</sub>O emission inhibition and NH<sub>3</sub> adsorption
- Soil functionalities and services (safe but varying effects)
- Dietary supplement effects

## Applicable? | **Material loop control**

High level of knowledge and certainty:

- Nutrient recovery levels
- K fertilizer value
- Fate of most elements incl. heavy metals
- Fate of common organic xenobiotics

More R&D required and/or higher level of uncertainty:

- Quality of micronutrients
- P uptake efficiency
- Fate of exotic xenobiotics